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(54) **HEAT TRANSFER FIN, FIN-TUBE HEAT EXCHANGER, AND HEAT PUMP DEVICE**

(57) A heat transfer fin (3A) includes: a base portion (4); a cylindrical collar portion (5) extending upwardly from the base portion (4); a protruding portion (51) protruding radially outwardly from a part of an upper end of the collar portion (5); and a wall portion (52) extending upwardly from a part of the upper end of the collar portion (5) other than the part of the upper end from which the protruding portion (51) protrudes. A height (B) from the base portion (4) to a top of the wall portion (52) is greater than a height (A) from the base portion (4) to a top of the protruding portion (51).

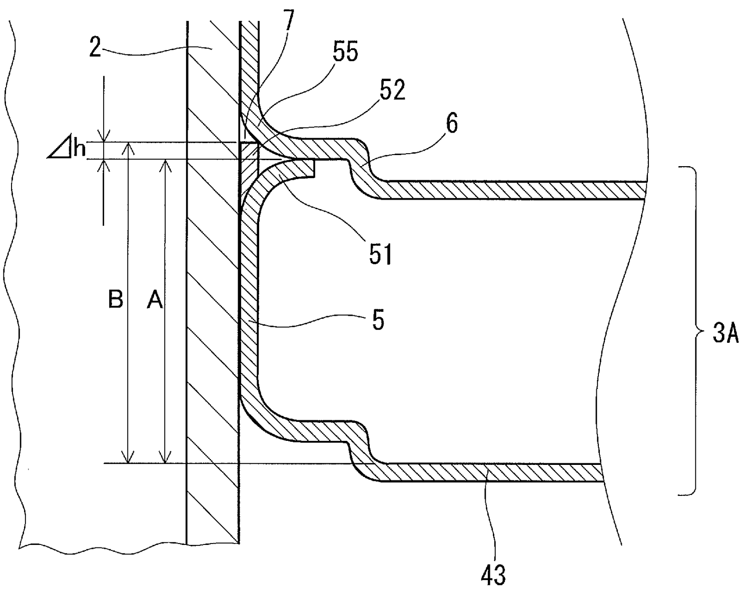

FIG.5

EP 2 778 593 A1

Description

TECHNICAL FIELD

[0001] The present invention relates to a fin-tube heat exchanger and a heat pump device including the fin-tube heat exchanger. The present invention also relates to a heat transfer fin suitable for use in a fin-tube heat exchanger.

BACKGROUND ART

[0002] Conventionally, heat exchangers serving as evaporators or condensers are used in air conditioning units such as household air conditioners, automobile air conditioners, and industrial packaged air conditioners, and heat pump devices such as refrigerators and heat pump water heaters. In particular, in household air conditioners and industrial packaged air conditioners, fin-tube heat exchangers are most commonly used.

[0003] FIG. 13 is a partial cross-sectional view of a fin-tube heat exchanger 100 used in a household air conditioner, an industrial packaged air conditioner, or the like. This heat exchanger 100 includes a stack of heat transfer fins 120 and a heat transfer tube 110 penetrating the stack of heat transfer fins 120. Each of the heat transfer fins 120 has a cylindrical collar portion 123 (having a uniform cross-sectional shape) extending upwardly from a base portion 121. A bottom portion 122 and a flared portion 124 extend radially outwardly in a curved manner from the bottom of the collar portion 123 and the upper end thereof, respectively. The flared portion 124 is in contact with the flat portion 121 of the adjacent heat transfer fin 120 in the vicinity of the bottom portion 122. In most cases, the heat transfer tube 110 having an outer diameter smaller than the inner diameter of the collar portion 123 is inserted into the collar portions 123 through the stack of the heat transfer fins 120, and then the heat transfer tube 110 is expanded. Thus, the heat transfer tube 110 is brought into close contact with the collar portions 123.

[0004] When the heat transfer fins 120 are stacked, gaps 130 are formed between the flared portions 124 and the adjacent bottom portions 122. Since the portions of the heat transfer tube 110 corresponding to these gaps 130 are not in contact with the heat transfer fins 120, the performance of heat transfer from the heat transfer tube 110 to the heat transfer fins 120 cannot be improved by conventional, commonly used mechanical tube expansion techniques.

[0005] Recently, Patent Literature 1 has proposed a method for improving the performance of heat transfer from the heat transfer tube 110 to the heat transfer fins 120. In this method, a filler such as a silicone resin is put into the gaps 130 and cured so as to fill the gaps 130.

CITATION LIST

Patent Literature

[0006] Patent Literature 1: JP 2010-169344 A

SUMMARY OF INVENTION

Technical Problem

[0007] However, since the method proposed in Patent Literature 1 requires a step of putting the filler in addition to the conventionally required common steps, improvements in the production process are needed, resulting in a significant increase in man hours. In addition, when the heat exchanger is discarded, not only metals commonly used for the heat transfer fins 120 and the heat transfer tube 110 but also the filler, a different type of material, must be disposed of. Therefore, it is difficult to separate the materials from one another. As a result, the recycling efficiency is reduced and the environmental impact is increased.

[0008] In view of these circumstances, it is an object of the present invention to provide a fin-tube heat exchanger capable of improving the performance of heat transfer from a heat transfer tube to heat transfer fins without using a filler, and a heat pump device including this fin-tube heat exchanger. It is another object of the present invention to provide a heat transfer fin suitable for use in a fin-tube heat exchanger.

Solution to Problem

[0009] The present disclosure provides a heat transfer fin including: a base portion; a cylindrical collar portion extending upwardly from the base portion; a protruding portion protruding radially outwardly from a part of an upper end of the collar portion; and a wall portion extending upwardly from a part of the upper end of the collar portion other than the part of the upper end from which the protruding portion protrudes, wherein a height from the base portion to a top of the wall portion is greater than a height from the base portion to a top of the protruding portion.

Advantageous Effects of Invention

[0010] The present disclosure can provide a heat transfer fin suitable for use in a fin-tube heat exchanger.

BRIEF DESCRIPTION OF DRAWINGS

[0011]

FIG. 1 is a configuration diagram of a heat exchanger according to a first embodiment of the present invention.
FIG. 2 is a partial cross-sectional view of the heat exchanger shown in FIG. 1.
FIG. 3 is a partial perspective view of a heat transfer fin in the first embodiment.
FIG. 4A is a cross-sectional view taken along the line IVA-IVA in FIG. 1.
FIG. 4B is a cross-sectional view taken along the line IVB-IVB in FIG. 1.
FIG. 5 is an enlarged cross-sectional view in which FIG. 4A and FIG. 4B are shown in one figure for explanation thereof.
FIG. 6 is another enlarged cross-sectional view in which FIG. 4A and FIG. 4B are shown in one figure for explanation thereof.
FIG. 7 is a partial perspective view of a heat transfer fin according to a modification of the first embodiment.
FIG. 8 is a partial perspective view of a heat transfer fin according to another modification of the first embodiment.
FIG. 9 is a partial perspective view of a heat transfer fin in a second embodiment of the present invention.
FIG. 10 is a partial perspective view of a heat transfer fin according to a modification of the second embodiment.
FIG. 11 is a partial perspective view of a heat transfer fin in a third embodiment of the present invention.
FIG. 12 is a configuration diagram of a room air conditioner as an example of a heat pump device in which a fin-tube heat exchanger is used.
FIG. 13 is a partial cross-sectional view of a conventional fin-tube heat exchanger.

DESCRIPTION OF EMBODIMENTS

[0012] A first aspect of the present disclosure provides a heat transfer fin including: a base portion; a cylindrical collar portion extending upwardly from the base portion; a protruding portion protruding radially outwardly from a part of an upper end of the collar portion; and a wall portion extending upwardly from a part of the upper end of the collar portion other than the part of the upper end from which the protruding portion protrudes, wherein a height from the base portion to a top of the wall portion is greater than a height from the base portion to a top of the protruding portion.
[0013] According to the above-described configuration, the protruding portions serve to support the adjacent heat transfer fins when they are stacked. On the other hand, when the heat transfer tube is inserted into the collar portions, a part of the upper end of each collar portion other than the part of the upper end on which the protruding portion is provided, that is, the wall portion, comes into contact with the heat transfer tube. Therefore, it is possible to ensure a larger contact area between each heat transfer fin and the heat transfer tube, and accordingly it is possible to reduce the gap between the adjacent heat transfer fins as much as possible. Therefore, it is possible to reduce the gap between the adjacent heat transfer fins as much as possible as a whole, with the adjacent heat transfer fins being stably stacked.
[0014] In addition, since the wall portion is formed on the upper end of each collar portion, the adjacent heat transfer fins are brought into contact with each other when they are stacked. Therefore, the heat transfer fins in the stack are integrated into a single unit and the performance of heat transfer of the entire stack is improved. As a result, heat of a fluid flowing in the heat transfer tube can be transferred more efficiently. The adjacent heat transfer fins in the stack may not be in complete contact with each other, but the heat transfer fins in the stack are integrated into a single unit and the performance of heat transfer of the entire stack is improved.
[0015] In addition, not only the collar portion but also the wall portion between the protruding portions comes into contact with the heat transfer tube. Therefore, the performance of heat transfer from the heat transfer tube to the heat transfer fins can be improved more than in conventional heat exchangers. Thereby, the heat exchange efficiency of the heat exchanger can be enhanced. In addition, unlike the conventional heat exchangers, there is no need to use a filler. Therefore, it is easy to separate the materials from one another when the heat exchanger is discarded, and the recycling efficiency does not decrease.
[0016] A second aspect of the present disclosure provides the heat transfer fin according to the first aspect, wherein the number of the protruding portions provided is at least two. According to this configuration, it is possible to stack the adjacent heat transfer fins stably while reducing the number of the protruding portions. As the number of the protruding portions is reduced, the contact area between the heat transfer fin and the heat transfer tube can be increased accordingly.
[0017] A third aspect of the present disclosure provides the heat transfer fin according to the second aspect, wherein

one of the at least two protruding portions extends in a specific direction, and another of the at least two protruding portions extends in a direction opposite to the specific direction. According to this configuration, it is possible to ensure sufficiently stable stacking of the heat transfer fins even if the number of the protruding portions is two.

[0018] A fourth aspect of the present disclosure provides the heat transfer fin according to the third aspect, wherein the specific direction is perpendicular to a longitudinal direction of the heat transfer fin. According to this configuration, it is possible to ensure sufficiently stable stacking of the heat transfer fins even if the number of the protruding portions is two.

[0019] A fifth aspect of the present disclosure provides the heat transfer fin according to the third aspect, wherein the specific direction is within an angular range of ± 30 degrees with respect to a straight line extending in a transverse direction perpendicular to a longitudinal direction of the heat transfer fin from a center of the collar portion. According to this configuration, it is possible to ensure sufficiently stable stacking of the heat transfer fins even if the number of the protruding portions is two.

[0020] A sixth aspect of the present disclosure provides the heat transfer fin according to any one of the first to fifth aspects, wherein the protruding portion is bent radially outwardly with distance from the upper end of the collar portion.

[0021] A seventh aspect of the present disclosure provides the heat transfer fin according to any one of the first to sixth aspects, wherein a notched portion is provided between the protruding portion and the wall portion.

[0022] An eighth aspect of the present disclosure provides the heat transfer fin according to any one of the first to fifth and seventh aspects, wherein the protruding portion has a center portion raised from an outer peripheral surface of a cylindrical body constituting the collar portion.

[0023] A ninth aspect of the present disclosure provides the heat transfer fin according to any one of the first to fifth and seventh aspects, wherein the protruding portion is a protrusion provided on an outer peripheral surface of a cylindrical body constituting the collar portion.

[0024] A tenth aspect of the present disclosure provides the heat transfer fin according to any one of the first to ninth aspects, further including a stepped portion that is curved and extends from a bottom of the collar portion down to the base portion to form a recess. According to this configuration, when the heat transfer fins are stacked, each stepped portion forms a recess into which the protruding portion of the adjacent heat transfer fin enters. Thereby, when the heat transfer fins are stacked during the production of the heat exchanger, even if the lower heat transfer fin is loaded by the weight of the upper heat transfer fin in the stack and the protruding portion of the lower heat transfer fin is deformed radially outwardly from the collar portion, the range in which the protruding portion is deformed is limited by the recess formed by the stepped portion. Therefore, it is possible to prevent the collar portion of the lower heat transfer fin in the stack from being deformed to have an inner diameter larger than that of the upper heat transfer fin in the stack. This means that when the heat transfer tube is inserted through the stack of the heat transfer fins and expanded to bring it into contact with the collar portions of the heat transfer fins, it is possible to prevent the contact area between the upper heat transfer fin in the stack and the heat transfer tube from differing from the contact area between the lower heat transfer fin in the stack and the heat transfer tube. Therefore, it is possible to achieve uniform heat transfer from the heat transfer tube to the heat transfer fins, regardless of where the heat transfer fins are located in the stack.

[0025] An eleventh aspect of the present disclosure provides a heat transfer fin including: a base portion; a cylindrical collar portion extending upwardly from the base portion; a protruding portion protruding radially outwardly from a part of an upper end of the collar portion; a wall portion extending upwardly from a part of the upper end of the collar portion other than the part of the upper end from which the protruding portion protrudes; and a stepped portion that is curved and extends from a bottom of the collar portion down to the base portion to form a recess.

[0026] According to this configuration, when the heat transfer fins are stacked, each stepped portion forms a recess into which the protruding portion of the adjacent heat transfer fin enters. Thereby, when the heat transfer fins are stacked during the production of the heat exchanger, even if the lower heat transfer fin is loaded by the weight of the upper heat transfer fin in the stack and the protruding portion of the lower heat transfer fin is deformed radially outwardly from the collar portion, the range in which the protruding portion is deformed is limited by the recess formed by the stepped portion. Therefore, it is possible to prevent the collar portion of the lower heat transfer fin in the stack from being deformed to have an inner diameter larger than that of the collar portion of the upper heat transfer fin in the stack. This means that when the heat transfer tube is inserted through the stack of the heat transfer fins and expanded to bring it into contact with the collar portions of the heat transfer fins, it is possible to prevent the contact area between the upper heat transfer fin in the stack and the heat transfer tube from differing from the contact area between the lower heat transfer fin in the stack and the heat transfer tube. Therefore, it is possible to achieve uniform heat transfer from the heat transfer tube to the heat transfer fins, regardless of where the heat transfer fins are located in the stack.

[0027] A twelfth aspect of the present disclosure provides a fin-tube heat exchanger including: a stack of heat transfer fins; and a heat transfer tube penetrating the stack of heat transfer fins, wherein each of the heat transfer fins includes: a base portion; a cylindrical collar portion extending upwardly from the base portion; a protruding portion protruding radially outwardly from a part of an upper end of the collar portion; and a wall portion extending upwardly from a part of the upper end of the collar portion other than the part of the upper end from which the protruding portion protrudes, and wherein a height from the base portion to a top of the wall portion is greater than a height from the base portion to a top of the protruding portion.

[0028] According to this configuration, the protruding portions serve to support the adjacent heat transfer fins when they are stacked. On the other hand, when the heat transfer tube is inserted into the collar portions, a part of the upper end of each collar portion other than the part of the collar portion on which the protruding portion is provided, that is, the wall portion, comes into contact with the heat transfer tube. Therefore, it is possible to ensure a larger contact area between each heat transfer fin and the heat transfer tube, and accordingly it is possible to reduce the gap between the adjacent heat transfer fins as much as possible. Therefore, it is possible to reduce the gap between the adjacent heat transfer fins as much as possible as a whole, with the adjacent heat transfer fins being stably stacked.

[0029] In addition, since the wall portion is formed on the upper end of each collar portion, the adjacent heat transfer fins are brought into contact with each other when they are stacked. Therefore, the heat transfer fins in the stack are integrated into a single unit and the performance of heat transfer of the entire stack is improved. As a result, heat of a fluid flowing in the heat transfer tube can be transferred more efficiently.

[0030] In addition, since the gap between the adjacent heat transfer fins can be reduced as much as possible, there is no need to fill the gap with a filler. Therefore, it is easy to separate the materials from one another when the heat exchanger is discarded, and the recycling efficiency is enhanced.

[0031] A thirteenth aspect of the present disclosure provides the fin-tube heat exchanger according to the twelfth aspect, wherein the number of the protruding portions provided is at least two. According to this configuration, it is possible to stack the adjacent heat transfer fins stably while reducing the number of the protruding portions. As the number of the protruding portions is reduced, the contact area between the heat transfer fin and the heat transfer tube can be increased accordingly.

[0032] A fourteenth aspect of the present disclosure provides the fin-tube heat exchanger according to the thirteenth aspect, wherein one of the at least two protruding portions extends in a specific direction, and another of the at least two protruding portions extends in a direction opposite to the specific direction. According to this configuration, it is possible to ensure sufficiently stable stacking of the heat transfer fins even if the number of the protruding portions is two.

[0033] A fifteenth aspect of the present disclosure provides the fin-tube heat exchanger according to the fourteenth aspect, wherein the specific direction is perpendicular to a longitudinal direction of the heat transfer fin. According to this configuration, it is possible to ensure sufficiently stable stacking of the heat transfer fins even if the number of the protruding portions is two.

[0034] A sixteenth aspect of the present disclosure provides the fin-tube heat exchanger according to the fourteenth aspect, wherein the specific direction is within an angular range of ± 30 degrees with respect to a straight line extending in a transverse direction perpendicular to a longitudinal direction of the heat transfer fin from a center of the collar portion. According to this configuration, it is possible to ensure sufficiently stable stacking of the heat transfer fins even if the number of the protruding portions is two.

[0035] A seventeenth aspect of the present disclosure provides the fin-tube heat exchanger according to any one of the twelfth to sixteenth aspects, wherein the protruding portion is bent radially outwardly with distance from the upper end of the collar portion.

[0036] A eighteenth aspect of the present disclosure provides the fin-tube heat exchanger according to any one of the twelfth to seventeenth aspects, wherein a notched portion is provided between the protruding portion and the wall portion.

[0037] A nineteenth aspect of the present disclosure provides the fin-tube heat exchanger according to any one of the twelfth to sixteenth and eighteenth aspects, wherein the protruding portion has a center portion raised from an outer peripheral surface of a cylindrical body constituting the collar portion.

[0038] A twentieth aspect of the present disclosure provides the fin-tube heat exchanger according to any one of the twelfth to sixteenth and eighteenth aspects, wherein the protruding portion is a protrusion provided on an outer peripheral surface of a cylindrical body constituting the collar portion.

[0039] A twenty-first aspect of the present disclosure provides the fin-tube heat exchanger according to any one of the twelfth to twentieth aspects, wherein the wall portion of one of the heat transfer fins in the stack is in contact with a back side of a bottom of the collar portion of another heat transfer fin that is stacked on the one heat transfer fin.

[0040] A twenty-second aspect of the present disclosure provides the fin-tube heat exchanger according to any one of the twelfth to twentieth aspects, wherein the wall portion of one of the heat transfer fins in the stack is not in contact with a back side of a bottom of the collar portion of another heat transfer fin that is stacked on the one heat transfer fin.

[0041] A twenty-third aspect of the present disclosure provides the fin-tube heat exchanger according to any one of the twelfth to twenty-second aspects, wherein each of the heat transfer fins further includes a stepped portion that is curved and extends from a bottom of the collar portion down to the base portion to form a recess. According to this configuration, when the heat transfer fins are stacked, each stepped portion forms a recess into which the protruding portion of the adjacent heat transfer fin enters. Thereby, when the heat transfer fins are stacked during the production of the heat exchanger, even if the lower heat transfer fin is loaded by the weight of the upper heat transfer fin in the stack and the protruding portion of the lower heat transfer fin is deformed radially outwardly from the collar portion, the range in which the protruding portion is deformed is limited by the recess formed by the stepped portion. Therefore, it is possible to prevent the collar portion of the lower heat transfer fin in the stack from being deformed to have an inner diameter larger than that of the collar portion of the upper heat transfer fin in the stack. This means that when the heat transfer tube is inserted through the stack of the heat transfer fins and expanded to bring it into contact with the collar portions of the heat transfer fins, it is possible to prevent the contact area between the upper heat transfer fin in the stack and the heat transfer tube from differing from the contact area between the lower heat transfer fin in the stack and the heat transfer tube. Therefore, it is possible to achieve uniform heat transfer from the heat transfer tube to the heat transfer fins, regardless of where the heat transfer fins are located in the stack.

[0042] A twenty-fourth aspect of the present disclosure provides the fin-tube heat exchanger according to any one of the twelfth to twenty-third aspects, wherein the protruding portion of one of the heat transfer fins in the stack enters the recess formed by the stepped portion of another heat transfer fin that is stacked on the one heat transfer fin.

[0043] A twenty-fifth aspect of the present disclosure provides the fin-tube heat exchanger according to the twenty-third aspect, wherein as long as the protruding portion of one of the heat transfer fins in the stack is in contact with the recess formed by the stepped portion of another heat transfer fin that is stacked on the one heat transfer fin, the height from the base portion to the top of the wall portion is greater than the height from the base portion to the top of the protruding portion.

[0044] A twenty-sixth aspect of the present disclosure provides the fin-tube heat exchanger according to any one of the twelfth to twenty-fifth aspects, wherein the wall portion of one of the heat transfer fins in the stack enters a space beneath a bottom of the collar portion of another heat transfer fin that is stacked on the one heat transfer fin. According to this configuration, it is possible to reduce the gap formed between one of the heat transfer fins in the stack and another heat transfer fin that is stacked on the one heat transfer fin as much as possible. Thereby, it is possible to increase the heat transfer area and thus enhance the heat exchange efficiency.

[0045] A twenty-seventh aspect of the present disclosure provides a heat pump device including: a compressor; a condenser; a throttling device; an evaporator; and a refrigerant circuit in which a refrigerant is circulated to pass through the compressor, the condenser, the throttling device, and the evaporator, wherein at least one of the condenser and the evaporator is the fin-tube heat exchanger according to any one of the twelfth to twenty-sixth aspects.

(Embodiments)

[0046] Hereinafter, embodiments of the present invention will be described with reference to the drawings. However, the present invention is not limited to the following embodiments.

(First Embodiment)

[0047] FIG. 1 shows a fin-tube heat exchanger 1 according to the first embodiment of the present invention. This heat exchanger 1 includes a stack of heat transfer fins 3A, a pair of side plates 20 disposed on both sides of the stack of transfer fins 3A, and a plurality of U-shaped heat transfer tubes 2 penetrating the heat transfer fins 3A and the side plates 20.

[0048] Each of the heat transfer fins 3A extends in a specific direction, and the straight portions of the heat transfer tubes 2 are arranged at a constant pitch in the longitudinal direction of the heat transfer fins 3A. The straight portions of each heat transfer tube 2 are connected by a bent portion on the side of one of the side plates 20, and both ends of the heat transfer tube 2 protrude from the other side plate 20, and one end of the heat transfer tube 2 and one end of the adjacent heat transfer tubes 2 are connected by a bent pipe 21.

[0049] Each of the heat transfer tubes 2 is made of a metal such as copper having a high thermal conductivity. Each of the heat transfer fins 3A has a plate shape obtained by press-forming a thin aluminum plate, and is rectangular in plane view. The shape of the heat transfer fins 3A is not particularly limited as long as they have a shape extending in the specific direction. For example, it may be a polygonal shape extended in the specific direction, such as a rhombus or a trapezoid, or may be an elliptical shape.

[0050] Specifically, as shown in FIG. 2 to FIG. 4B, each of the heat transfer fins 3A includes a base portion 4 spreading around the straight portion of the heat transfer tube 2 and a cylindrical collar portion 5 extending upwardly from the base portion 4 along the straight portion of the heat transfer tube 2. Hereinafter, for the purpose of explanation, the direction in which the collar portion 5 extends is referred to as an upward direction and the direction opposite to the upward direction is referred to as a downward direction.

[0051] The collar portion 5 forms an insertion hole into which the heat transfer tube 2 is to be inserted. The heat transfer tube 2 has an initial outer diameter smaller than the inner diameter of the collar portion 5. After the heat transfer fins 3A are stacked so that their insertion holes coincide with each other, the heat transfer tube 2 is inserted through the insertion holes. That is, a clearance is provided between the initial heat transfer tube 2 and the collar portions 5 so as to facilitate the insertion of the heat transfer tube 2. Then, the heat transfer tube 2 is expanded by a mechanical tube expanding technique in which a tube expanding billet is inserted into the heat transfer tube 2. Thereby, the heat transfer tube 2 comes into contact with the collar portions 5, and the collar portions 5 are coaxially fixed together.

[0052] The collar portion 5 is provided with, on its lower end, a bottom portion 55 that is curved and extends radially outwardly from the bottom of the collar portion 5 down to the base portion 4. On the other hand, on the upper end of the collar portion 5, a plurality of protruding portions 51 and a plurality of wall portions 52 are alternately arranged in the circumferential direction. The number of the protruding portions 51 is equal to the number of the wall portions 52.

[0053] The base portion 4 may be flat, but in the present embodiment, it has a corrugated shape having folds parallel to the longitudinal direction of the heat transfer fins 3A. The folds of the corrugated shape need not necessarily be parallel to the longitudinal direction of the heat transfer fins 3A. They may be inclined with respect to the longitudinal direction. Specifically, the base portion 4 includes a corrugated portion 41 having ridges and grooves, a flat ring portion 43 surrounding the heat transfer tube 2 at the same level as the grooves of the corrugated portion 41, and a peripheral wall portion 42 extending in a tapered manner from the outer edge of the ring portion 43 to the ridges of the corrugated portion 41. The above-mentioned bottom portion 55 extends down to the inner edge of the ring portion 43.

[0054] Each of the protruding portion 51 protrudes radially outwardly from a part of the upper end of the collar portion 5. The wall portion 52 extends upwardly from a part of the upper end of the collar portion 5 other than the part of the upper end from which the protruding portion 51 protrudes. In other words, the wall portion 52 is formed by extending the collar portion 5 to a region between the protruding portions 51. In the adjacent heat transfer fins 3A, as shown in FIG. 4A, the protruding portion 51 of one heat transfer fin 3A is in contact with the ring portion 43 of the adjacent heat transfer fin 3A in the vicinity of the bottom portion 55.

[0055] In the present embodiment, a stepped portion that is curved and extends from the bottom of the collar portion 5 down to the base portion 4 to form a recess is provided. Specifically, the ring portion 43 is provided with the stepped portion 6 so as to form a recess, into which the protruding portions 51 can be fitted, around the bottom portion 55. That is, the stepped portion 6 has an inner diameter larger than the diameter of a circle circumscribing the protruding portions 51. The cross-sectional shape of the stepped portion 6 may be a straight line parallel or oblique to the axial direction of the collar portion 5, or may be a curved line. In this configuration, when the heat transfer fins 3A are stacked during the production of the heat exchanger, even if the lower heat transfer fin 3A is loaded by the weight of the upper heat transfer fin 3A in the stack and the protruding portion 51 of the lower heat transfer fin 3A is deformed radially outwardly from the collar portion 5, the range in which the protruding portion 51 is deformed is limited by the recess formed by the stepped portion 6. Therefore, it is possible to prevent the collar portion 5 of the lower heat transfer fin 3A in the stack from being deformed to have an inner diameter larger than that of the collar portion 5 of the upper heat transfer fin 3A in the stack. This means that when the heat transfer tube 2 is inserted through the stack of the heat transfer fins 3A and expanded to bring it into contact with the collar portions 5 of the heat transfer fins 3A, it is possible to prevent the contact area between the upper heat transfer fin 3A in the stack and the heat transfer tube 2 from differing from the contact area between the lower heat transfer fin 3A in the stack and the heat transfer tube 2. Therefore, it is possible to achieve uniform heat transfer from the heat transfer tube 2 to the heat transfer fins 3A, regardless of where the heat transfer fins 3A are located in the stack.

[0056] The protruding portions 51 serve to support the adjacent heat transfer fins 3A when they are stacked. Therefore, it is desirable that the heights from the ring portion 43 to the tops of all the protruding portions 51 be equal. Furthermore, it is preferable that the protruding portions 51 be arranged at regular angular intervals in the circumferential direction.

[0057] The number of the protruding portions 51 is not particularly limited, but it is desirable that at least two protruding portions 51 be provided. From the viewpoint of the stability of the stack of the heat transfer fins 3A in the transverse direction perpendicular to the longitudinal direction of the heat transfer fins 3A (the heat transfer fins 3A are supported more stably by two or more protruding portions 51 in the longitudinal direction), it is preferable that at least two protruding portions 51 be respectively disposed in two separate regions within a specific angular range spreading in the transverse direction of the heat transfer fin 3A from the center of the collar portion 5 (for example, in two separate regions within an angular range of ± 30 degrees with respect to a straight line extending in the transverse direction). For example, three protruding portions 51 may be disposed in such a manner that one of them is disposed in one region within the angular range and the other two are disposed in the other region within the angular range and that the center lines of these three protruding portions 51 form a Y-shaped configuration in plane view (as viewed from the axial direction of the collar portion 5). Alternatively, two protruding portions 51 may be respectively disposed in two separate regions within the specific angular range, that is, at two separate positions deviated from a straight line passing through the center of the collar portion 5 and extending in the transverse direction. However, from the viewpoint of increasing the stability while ensuring a large contact area between the wall portions 52 and the heat transfer tube 2, the best configuration is that only two protruding portions 51 protruding in the opposite directions along the transverse direction of the heat transfer fin 3A are provided. In other words, one of these two protruding portions 51 extends in a specific direction. The other one of the two protruding portions 51 extends in a direction opposite to the specific direction. More specifically, the specific direction is a direction (transverse direction) perpendicular to the longitudinal direction of the heat transfer fin 3A.

[0058] In the present embodiment, each protruding portion 51 is bent radially outwardly with distance from the upper end of the collar portion 5 and finally bent at 90 degrees with respect to the collar portion 5. However, the protruding portion 51 need not necessarily be curved. For example, the protruding portion 51 may be formed of a linear gradient portion extending obliquely upward from the collar portion 5 and a flange portion provided on the upper end of the linear gradient portion. The bending angle also is not limited to 90 degrees.

[0059] Preferably, the circumferential width of each protruding portion 51 is smaller than the circumferential width of each protruding portion 51. For example, the circumferential width of each protruding portion 51 is about one twelfth to one fifth the perimeter of the collar portion 5.

[0060] In the present embodiment, each protruding portion 51 has sharp corners and its plane view is a circular arc shape with a certain width. However, the corners of the protruding portion 51 may be rounded, as shown in FIG. 7, to prevent the sharp corners from damaging something when the heat transfer fins 3A are stacked. The protruding portion 51 may have a crescent shape in plane view.

[0061] On the other hand, the wall portions 52 come into contact with the heat transfer tube 2, although they do not serve to support the adjacent heat transfer fins 3A. The inner diameter of a circle connecting the wall portions 52 is equal to the inner diameter of the collar portion 5, and the wall portions 52 and the collar portion 5 form a continuous wall surface. Specifically, when the heat transfer fins 3A are stacked, a gap 7 is formed between the protruding portion 51 and the bottom portion 55 of the upper heat transfer fin 3A, as shown in FIG. 4A, but a much smaller gap is formed between the wall portion 52 and the bottom portion 55 of the upper heat transfer fin 3A, as shown in FIG. 4B.

[0062] From the viewpoint of inserting the wall portion 52 deeply into the space beneath the the bottom portion 55 of the upper heat transfer fin 3A and thereby reducing the gap between the wall portion 52 and the bottom portion 55 as much as possible, the height B from the ring portion 43 (base portion 4) to the top of the wall portion 52 is greater than the height A from the ring portion 43 (base portion 4) to the top of the protruding portion 51. That is, the top of the wall portion 52 is located higher than the top of the protruding portion 51 by the difference Δh between the height B from the ring portion 43 (base portion 4) to the top of the wall portion 52 and the height A from the ring portion 43 (base portion 4) to the top of the protruding portion 51. In this configuration, not only the gap 7 can be reduced by the difference Δh, but also the contact area between the heat transfer fin 3A and the heat transfer tube 2 is increased. Therefore, the heat transfer area increases and thus the heat exchange efficiency improves. If the height B from the ring portion 43 (base portion 4) to the top of the wall portion 52 is smaller than the height A from the ring portion 43 (base portion 4) to the top of the protruding portion 51, the lateral surface of the heat transfer tube 2 is exposed between the adjacent heat transfer fins 3A when the heat transfer fins 3A are stacked. This is an undesirable tendency in terms of the heat transfer efficiency. In addition, since the wall portions 52 are formed on the upper end of the collar portion 5, the adjacent heat transfer fins 3A are brought into contact with each other when they are stacked. Therefore, the heat transfer fins 3A in the stack are integrated into a single unit and the performance of heat transfer of the entire stack is improved. As a result, heat of a fluid flowing in the heat transfer tube 2 can be transferred more efficiently.

[0063] As shown in FIG. 5, the wall portion 52 of one of the heat transfer fins 3A in the stack may be in contact with the back side of the bottom of the collar portion 5 of another heat transfer fin 3A that is stacked on the one heat transfer fin 3A. Alternatively, as shown in FIG. 6, the wall portion 52 of one of the heat transfer fins 3A in the stack need not be in contact with the back side of the bottom of the collar portion 5 of another heat transfer fin 3A that is stacked on the one heat transfer fin 3A. In the stacked heat transfer fins 3A, some of the wall portions 52 may be in contact with the back sides of the bottoms of the collar portions 52, and the other wall portions 52 may not be in contact with the back sides of the bottoms of the collar portions 52. For example, when the heat transfer fins 3A are stacked during the production of the heat exchanger, in the heat transfer fins 3A located in the lower part of the stack, the wall portion 52 is more likely to come into contact with the back side of the bottom of the adjacent collar portion 5 by the weight thereof. In contrast, in some of the heat transfer fins 3A located in the upper part of the stack, the wall portion 52 may not come into contact with the back side of the bottom of the adjacent collar portion 5. However, the stacked heat transfer fins 3A are integrated into a single unit and the performance of heat transfer of the entire stack is improved.

[0064] As shown in FIG. 4A, the protruding portion 51 of one of the heat transfer fins 3A in the stack enters the recess formed by the stepped portion 6 of another heat transfer fin 3A that is stacked on the one heat transfer fin 3A. As shown in FIG. 4B, the wall portion 52 of one of the heat transfer fins 3A in the stack enters the space beneath the bottom of the collar portion 5 of another heat transfer fin 3A that is stacked on the one heat transfer fin 3A. As shown in FIG. 5, as long as the protruding portion 51 of one of the heat transfer fins 3A in the stack is in contact with the recess formed by the stepped portion 6 of another heat transfer fin 3A that is stacked on the one heat transfer fin 3A, the height B from the base portion 4 to the top of the wall portion 52 need only be greater than the height A from the base portion 4 to the top of the protruding portion 51.

[0065] In the present embodiment, a thin linear slit is provided between the protruding portion 51 and the wall portion 52. However, in order to reduce the stress concentrated on the boundary between the protruding portion 51 and the wall 52, it is preferable to provide, between the protruding portion 51 and the wall portion 52, a notch 53 (an example of a notched portion) having an arc-shaped bottom with a certain width and smoothly connecting the protruding portion 51 and the wall portion 52, as shown in FIG. 8.

[0066] Here, the details of heat transfer phenomena are described with reference to the conventional fin-tube heat exchanger 100 shown in FIG. 13.

[0067] The heat of a fluid flowing in the heat transfer tube 110 is transferred from the outer peripheral surface of the heat transfer tube 110 to the inner peripheral surface of the collar portion 123, and then is conducted to the outer peripheral surface of the collar portion 123 and the upper surface and the lower surface of the base portion 121. The heat thus conducted to the outer peripheral surface of the collar portion 123 and the upper surface and the lower surface of the base portion 121 is transferred to a fluid that is to flow between the base portions 121.

[0068] In the case where the heat is transferred from the outer peripheral surface of the heat transfer tube 110 to the inner peripheral surface of the collar portion 5, the thermal contact conductance is generally defined by the following equation 1:

[Equation 1]

$$K=\frac{1.7\times10^{5}}{\frac{\delta_1+\delta_0}{\lambda_1}+\frac{\delta_2+\delta_0}{\lambda_2}}\frac{0.6P}{H}+\frac{10^{6}\lambda_f}{\delta_1+\delta_2}$$

where K is the thermal contact conductance (W/m^2 • K), δ_1 is the surface roughness (μm) of one of two members in contact at the interface, δ_2 is the surface roughness (μm) of the other one of the members in contact at the interface, δ_0 is the equivalent length of the contact (= 23 μm), λ_1 is the thermal conductivity (W/m • K) of the one of the members in contact at the interface, λ_2 is the thermal conductivity (W/m • K) of the other one of the members in contact at the interface, P is the contact pressure (MPa), H is the hardness (Hb) of a softer one of the members in contact at the interface, and λ_f is the thermal conductivity (W/m • K) of an interstitial fluid.

[0069] The thermal contact resistance Rc is calculated from the following equation 2 using the thermal contact conductance K obtained by the above equation 1.

[Equation 2]

$$Rc = 1/(K \times S)$$

where Rc is the thermal contact resistance (K/W) and S is the contact area (m^2).

[0070] Therefore, there are two ways to reduce the thermal contact resistance Rc: one is to increase the thermal contact conductance K; and the other is to increase the contact area S.

[0071] As a way to increase the thermal contact conductance K, there is a method of filling the gaps 130 between the collar portions 123 with a filler, as described in Patent Literature 1, for example. With the use of the filler instead of the interstitial fluid, which is usually air, this method makes it possible to increase the thermal conductivity λ_f of the interstitial fluid and thus increase the thermal contact conductance K.

[0072] However, if the filler is used, the materials of the heat exchanger 100 include not only the materials of the heat transfer fins 120 and the heat transfer tube 110 but also the filler as a different type of material. Therefore, it is difficult to separate the materials from one another for recycling when the product is discarded. As a result, the recycling efficiency decreases, which leads to a decrease in the recycling rate, an increase in the energy required for recycling, etc., and consequently in an increase in the environmental impact.

[0073] Recently, efforts to reduce the impact on the global environment, for example, the implementation of the Home Appliance Recycling Act, have been made at the initiative of the Japanese government. Since the number of products subject to the Recycling Act tends to be increased, the recycling efficiency is a non-negligible factor.

[0074] In addition to the above-mentioned method, there are many other ways to increase the thermal contact conductance K. For example, there are a method of reducing the surface roughnesses δ_1 and δ_2 of the surfaces of the heat transfer tube 110 and the collar portion 123 in contact, a method of increasing the contact pressure P, a method of increasing the thermal conductivities λ_1 and λ_2 of the heat transfer tube 110 and the heat transfer fin 120, and a method of reducing the hardness H of the softer one of the heat transfer tube 110 and the heat transfer fin 120. The present invention focuses on the method of increasing the contact area S.

[0075] An increase in the contact area between the heat transfer tube 110 and the heat transfer fin 120 makes it possible to reduce the thermal contact resistance Rc without changing the thermal contact conductance K, and thus to improve the performance of heat transfer from the heat transfer tube 110 to the heat transfer fin 120.

[0076] As described above, in the heat exchanger 1 of the present embodiment, not only the collar portions 5 but also the wall portions 52 between the protruding portions 51 come into contact with the heat transfer tube 2. Therefore, the performance of heat transfer from the heat transfer tube 2 to the heat transfer fins 3A can be improved more than in conventional heat exchangers. Thereby, the heat exchange efficiency of the heat exchanger 1 can be improved. In addition, unlike the conventional heat exchangers, the heat exchanger 1 does not require a filler. Therefore, it is easy to separate the materials from one another when the heat exchanger is discarded, and the recycling efficiency does not decrease.

<Heat Pump Device>

[0077] Next, a room air conditioner 10 as an example of a heat pump device, in which the above-described heat exchanger 1 is used, is described with reference to FIG. 12.

[0078] In the room air conditioner 10, a refrigerant circuit 10C is configured to pass through both an indoor unit 10A and an outdoor unit 10B. A compressor 11 (for example, a rotary compressor), a four-way valve 12, an outdoor heat exchanger 13, a throttling device 14 (for example, an expansion valve) are disposed in the outdoor unit 10B. An indoor heat exchanger 15 is disposed in the indoor unit 10A. The outdoor unit 10B is provided with an outdoor fan 16 (for example, a propeller fan) for supplying outdoor air to the outdoor heat exchanger 13, and the indoor unit 10A is provided with an indoor fan 17 (for example, a cross flow fan) for supplying indoor air to the indoor heat exchanger 15.

[0079] In the room air conditioner 10, a high-temperature and high-pressure refrigerant compressed by the compressor 11 is directed through the four-way valve 12 to the indoor heat exchanger 15 in heating operation and to the outdoor heat exchanger 13 in cooling operation. In the heating operation, the indoor heat exchanger 15 serves as a condenser, into which the high-temperature refrigerant is introduced through the four-way valve 12. The indoor heat exchanger 15 allows the high-temperature refrigerant introduced thereinto to transfer its heat to the indoor air supplied by the indoor fan 17 through heat exchange between the refrigerant and the air so as to condense and liquefy the refrigerant. The liquefied refrigerant is adiabatically expanded by the throttling device 14, and the resulting low-temperature and low-pressure refrigerant is supplied to the outdoor heat exchanger 13. The outdoor heat exchanger 13 serves as an evaporator, and allows the vapor-liquid two-phase low-temperature refrigerant to absorb the heat of the outdoor air supplied by the outdoor fan 16 through heat exchange between the refrigerant and the air so as to evaporate and vaporize the refrigerant. The evaporated low-pressure vapor refrigerant is again compressed by the compressor 11. The indoor air is heated by repeating this cycle continuously. Thus, the room is heated. In the cooling operation, the refrigerant is caused to flow in the reverse direction by switching the four-way valve 12 so as to cool the indoor air. Thus, the room is cooled. That is, in both the heating operation and the cooling operation, the refrigerant circulating in the refrigerant circuit 10C passes through the compressor 11, the condenser, the throttling device 14, and the evaporator in this order.

[0080] When the heat exchanger 1 of the present embodiment is used as at least one of the condenser and the evaporator in the room air conditioner 10 as described above or any other heat pump device, the heat exchange efficiency of the condenser and/or the evaporator can be improved. As a result, the COP (coefficient of performance) of the heat pump device can be improved.

(Second Embodiment)

[0081] Next, a fin-tube heat exchanger according to the second embodiment of the present invention is described with reference to FIG. 9. In the present embodiment, the same components as those in the first embodiment are denoted by the same reference numerals, and the description thereof may be omitted. This also applies to the third embodiment described later.

[0082] In the present embodiment, a heat transfer fin 3B having a shape shown in FIG. 9 is used. This heat transfer fin 3B has the same configuration as the heat transfer fin 3A used in the first embodiment, except for the shape of the protruding portions 51. The height from the base portion 4 to the top of the wall portion 52 is greater than the height from the base portion 4 to the top of the protruding portion 51.

[0083] Specifically, in the present embodiment, each protruding portion 51 is formed continuously from the wall portions 52 on both sides thereof, and has a shape in which the circumferential center thereof is gradually raised with distance from the upper end of the collar portion 5. In other words, each protruding portion 51 has a spout-like shape with a pointed arch-shaped cross section (such as a bird's beak-shaped or V-shaped cross section).

[0084] When the heat transfer fins 3B are stacked, the protruding portions 51 serve to support the adjacent heat transfer fins 3B. Therefore, the protruding portions 51 need to support the weight of all the upper located heat transfer fins 3B. In this regard, the spout-like protruding portions 51 of the present embodiment can have a higher section modulus. Therefore, the strength of the protruding portions 51 themselves can be increased. The wall portions 52 have the same effect as in the first embodiment.

[0085] In FIG. 9, the protruding portion 51 has a pointed arch-shaped cross section with a sharp corner at the center thereof, but the center of the protruding portion 51 may be smoothly curved as shown in FIG. 10 to prevent the sharp corner from damaging something when the heat transfer fins 3B are stacked.

(Third Embodiment)

[0086] Next, a fin-tube heat exchanger according to the second embodiment of the present invention is described with reference to FIG. 11. In the present embodiment, a heat transfer fin 3C having a shape shown in FIG. 11 is used. This heat transfer fin 3C has the same configuration as the heat transfer fin 3A used in the first embodiment, except for the shape of the protruding portions 51. The height from the base portion 4 to the top of the wall portion 52 is greater than the height from the base portion 4 to the top of the protruding portion 51.
[0087] Specifically, in the present embodiment, each protruding portion 51 is a protrusion provided on the outer peripheral surface of a continuous cylindrical body including the collar portion 5 and the wall portion 52. The protrusion has a linear tab-like shape extending in the axial direction of the collar portion 5. This configuration also produces the same effects as in the first embodiment.

INDUSTRIAL APPLICABILITY

[0088] The fin-tube heat exchanger of the present invention is applicable to heat pump devices for use in air conditioning units such as household air conditioners, automobile air conditioners, and industrial packaged air conditioners, refrigerators, heat pump water heaters, etc.

Claims

1. A heat transfer fin comprising:

   a base portion;
   a cylindrical collar portion extending upwardly from the base portion;
   a protruding portion protruding radially outwardly from a part of an upper end of the collar portion; and
   a wall portion extending upwardly from a part of the upper end of the collar portion other than the part of the upper end from which the protruding portion protrudes,
   wherein a height from the base portion to a top of the wall portion is greater than a height from the base portion to a top of the protruding portion.

2. The heat transfer fin according to claim 1, wherein the number of the protruding portions provided is at least two.

3. The heat transfer fin according to claim 2, wherein one of the at least two protruding portions extends in a specific direction, and another of the at least two protruding portions extends in a direction opposite to the specific direction.

4. The heat transfer fin according to claim 3, wherein the specific direction is perpendicular to a longitudinal direction of the heat transfer fin.

5. The heat transfer fin according to claim 3, wherein the specific direction is within an angular range of ± 30 degrees with respect to a straight line extending in a transverse direction perpendicular to a longitudinal direction of the heat transfer fin from a center of the collar portion.

6. The heat transfer fin according to claim 1, wherein the protruding portion is bent radially outwardly with distance from the upper end of the collar portion.

7. The heat transfer fin according to claim 1, wherein a notched portion is provided between the protruding portion and the wall portion.

8. The heat transfer fin according to claim 1, wherein the protruding portion has a center portion raised from an outer peripheral surface of a cylindrical body constituting the collar portion.

9. The heat transfer fin according to claim 1, wherein the protruding portion is a protrusion provided on an outer peripheral surface of a cylindrical body constituting the collar portion.

10. The heat transfer fin according to claim 1, further comprising a stepped portion that is curved and extends from a bottom of the collar portion down to the base portion to form a recess.

11. A heat transfer fin comprising:

a base portion;
a cylindrical collar portion extending upwardly from the base portion;
a protruding portion protruding radially outwardly from a part of an upper end of the collar portion;
a wall portion extending upwardly from a part of the upper end of the collar portion other than the part of the upper end from which the protruding portion protrudes; and
a stepped portion that is curved and extends from a bottom of the collar portion down to the base portion to form a recess.

12. A fin-tube heat exchanger comprising:

a stack of heat transfer fins; and
a heat transfer tube penetrating the stack of heat transfer fins,
wherein each of the heat transfer fins comprises:

a base portion;
a cylindrical collar portion extending upwardly from the base portion;
a protruding portion protruding radially outwardly from a part of an upper end of the collar portion; and
a wall portion extending upwardly from a part of the upper end of the collar portion other than the part of the upper end from which the protruding portion protrudes, and

wherein a height from the base portion to a top of the wall portion is greater than a height from the base portion to a top of the protruding portion.

13. The fin-tube heat exchanger according to claim 12, wherein the number of the protruding portions provided is at least two.

14. The fin-tube heat exchanger according to claim 13, wherein one of the at least two protruding portions extends in a specific direction, and another of the at least two protruding portions extends in a direction opposite to the specific direction.

15. The fin-tube heat exchanger according to claim 14, wherein the specific direction is perpendicular to a longitudinal direction of the heat transfer fin.

16. The fin-tube heat exchanger according to claim 14, wherein the specific direction is within an angular range of ± 30 degrees with respect to a straight line extending in a transverse direction perpendicular to a longitudinal direction of the heat transfer fin from a center of the collar portion.

17. The fin-tube heat exchanger according to claim 12, wherein the protruding portion is bent radially outwardly with distance from the upper end of the collar portion.

18. The fin-tube heat exchanger according to claim 12, wherein a notched portion is provided between the protruding portion and the wall portion.

19. The fin-tube heat exchanger according to claim 12, wherein the protruding portion has a center portion raised from an outer peripheral surface of a cylindrical body constituting the collar portion.

20. The fin-tube heat exchanger according to claim 12, wherein the protruding portion is a protrusion provided on an outer peripheral surface of a cylindrical body constituting the collar portion.

21. The fin-tube heat exchanger according to claim 12, wherein the wall portion of one of the heat transfer fins in the stack is in contact with a back side of a bottom of the collar portion of another heat transfer fin that is stacked on the one heat transfer fin.

22. The fin-tube heat exchanger according to claim 12, wherein the wall portion of one of the heat transfer fins in the stack is not in contact with a back side of a bottom of the collar portion of another heat transfer fin that is stacked on the one heat transfer fin.

23. The fin-tube heat exchanger according to claim 12, wherein each of the heat transfer fins further comprises a stepped portion that is curved and extends from a bottom of the collar portion down to the base portion to form a recess.

24. The fin-tube heat exchanger according to claim 23, wherein the protruding portion of one of the heat transfer fins in the stack enters the recess formed by the stepped portion of another heat transfer fin that is stacked on the one heat transfer fin.

25. The fin-tube heat exchanger according to claim 23, wherein as long as the protruding portion of one of the heat transfer fins in the stack is in contact with the recess formed by the stepped portion of another heat transfer fin that is stacked on the one heat transfer fin, the height from the base portion to the top of the wall portion is greater than the height from the base portion to the top of the protruding portion.

26. The fin-tube heat exchanger according to claim 23, wherein the wall portion of one of the heat transfer fins in the stack enters a space beneath a bottom of the collar portion of another heat transfer fin that is stacked on the one heat transfer fin.

27. A heat pump device comprising:

a compressor;
a condenser;
a throttling device;
an evaporator; and
a refrigerant circuit in which a refrigerant is circulated to pass through the compressor, the condenser, the throttling device, and the evaporator,
wherein at least one of the condenser and the evaporator is the fin-tube heat exchanger according to claim 12.

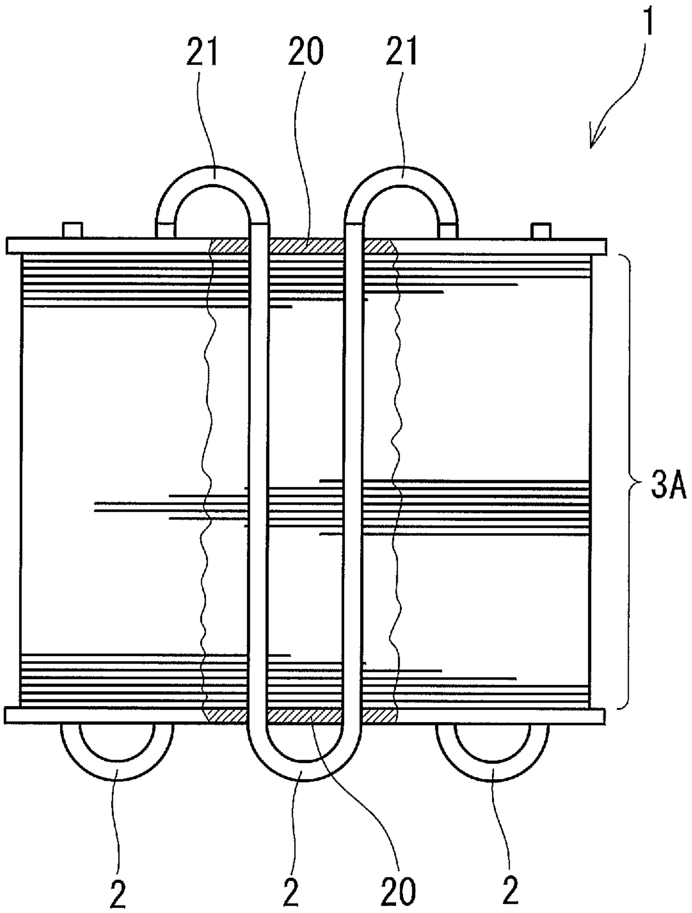

FIG.1

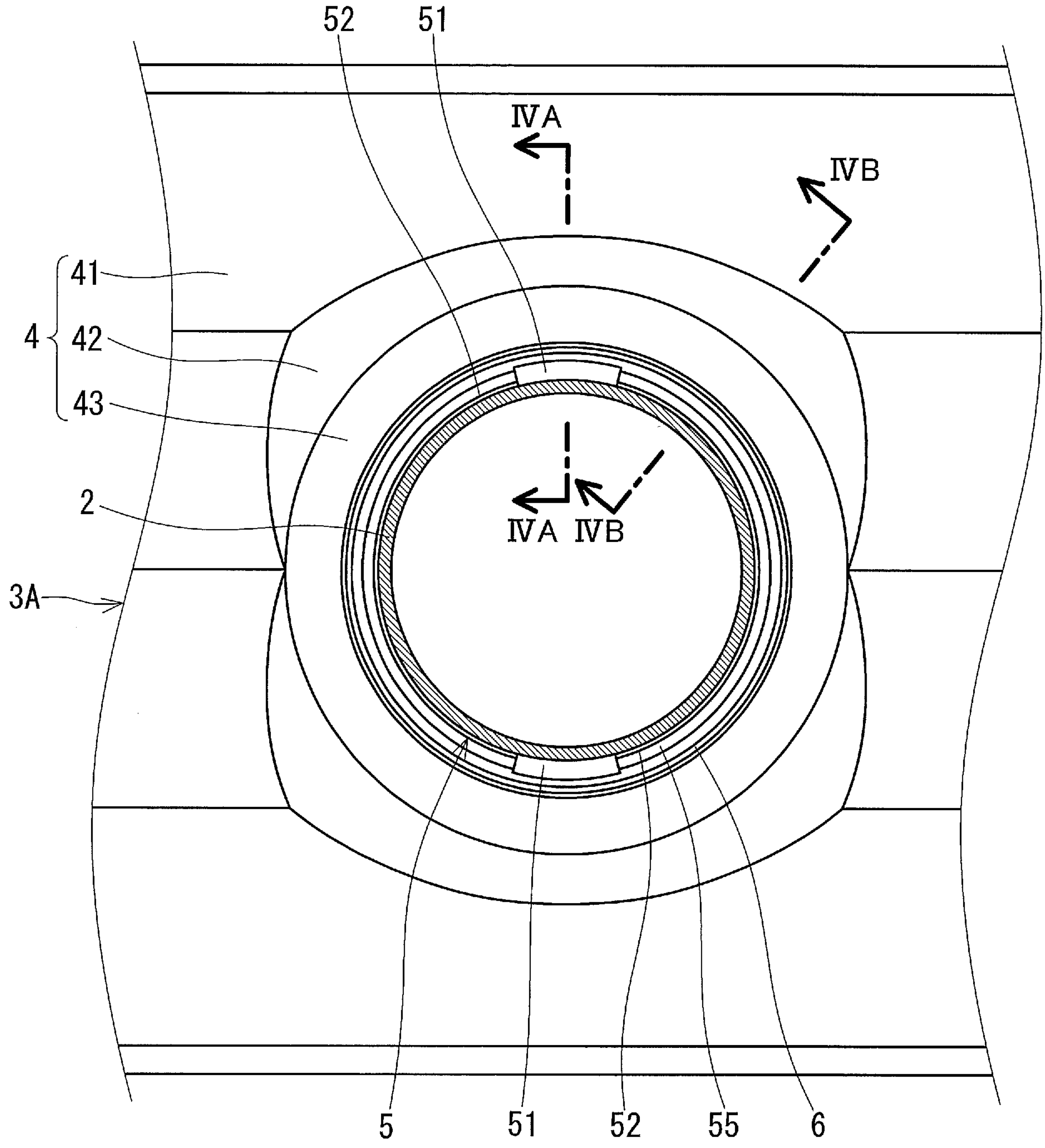

FIG.2

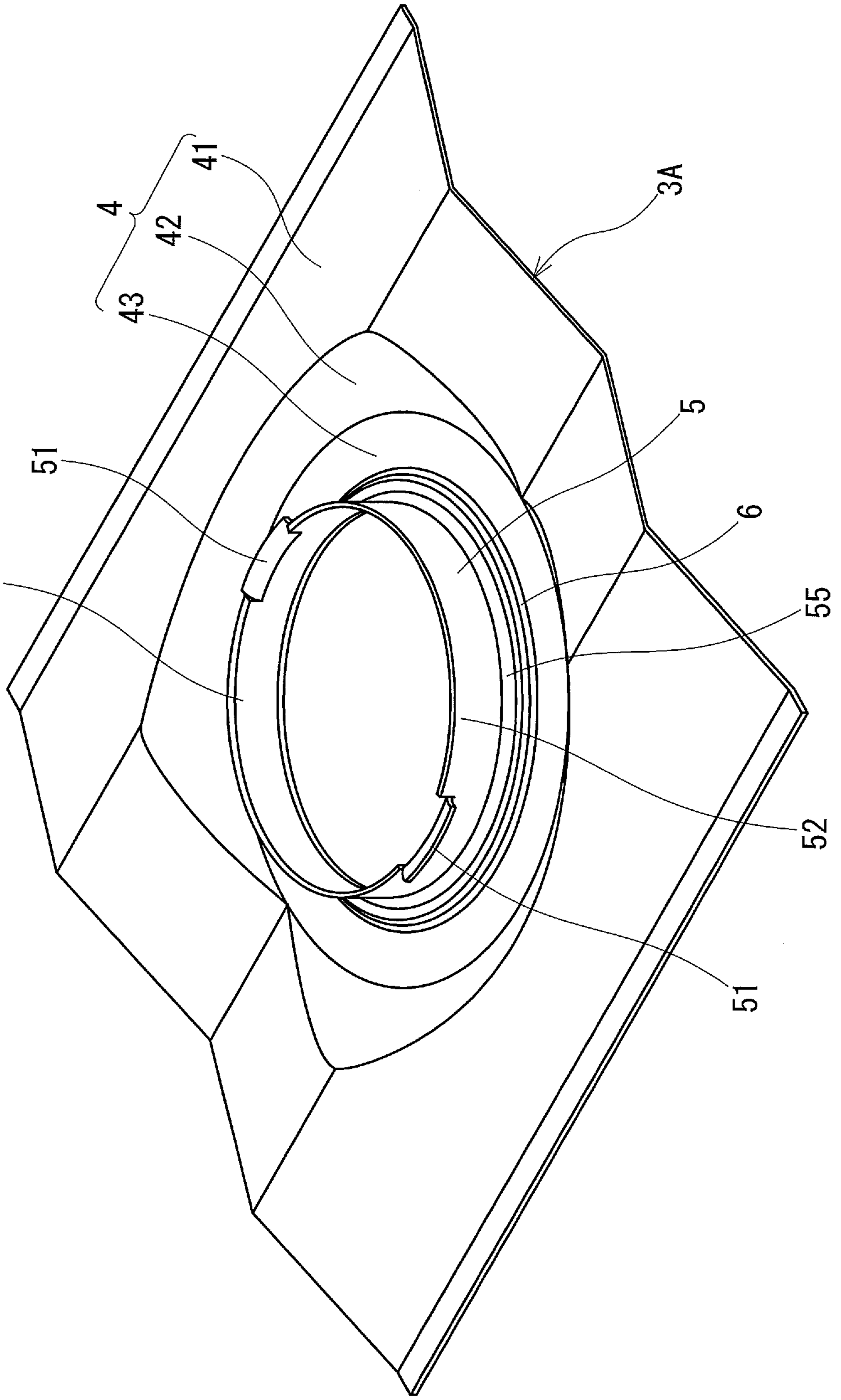

FIG.3

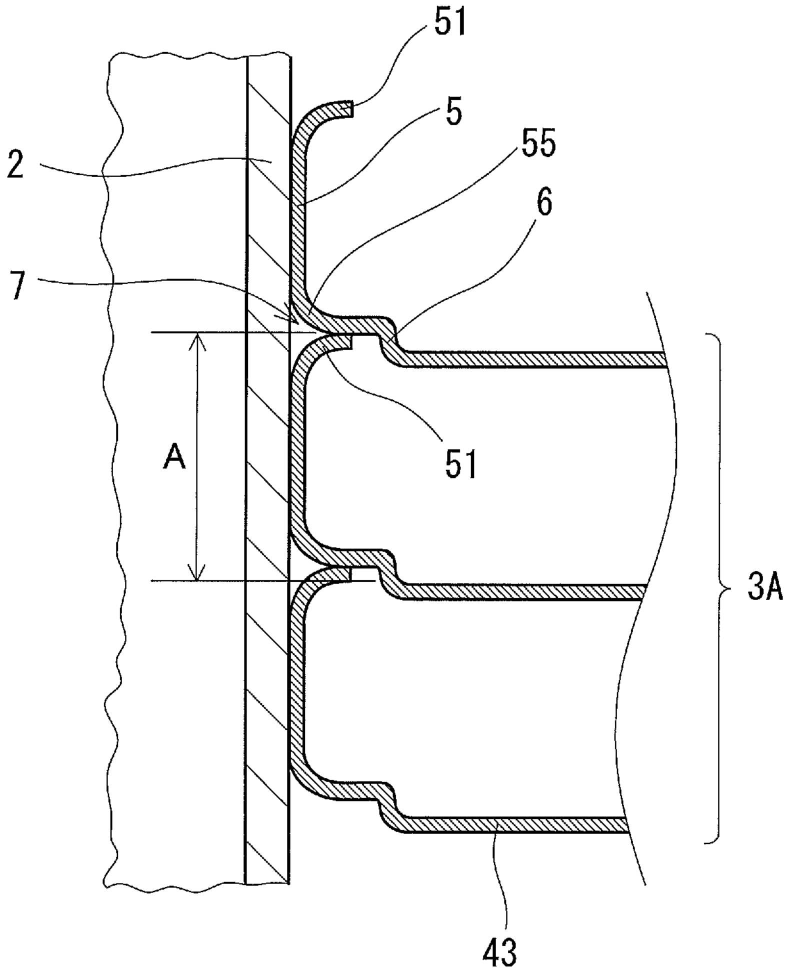

FIG.4A

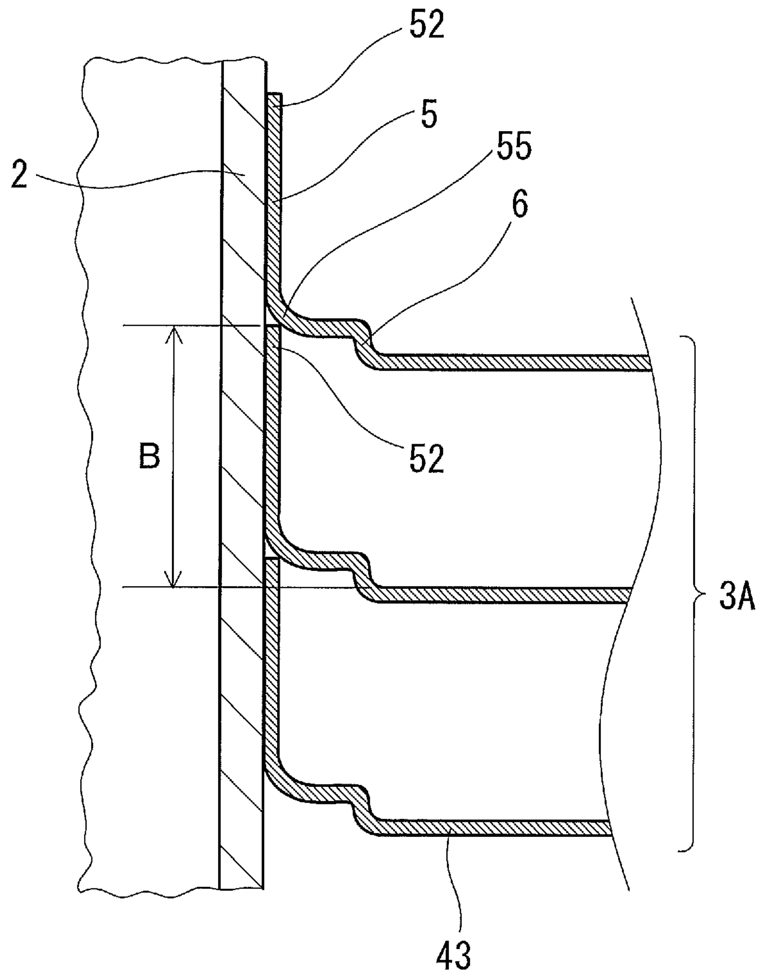

FIG.4B

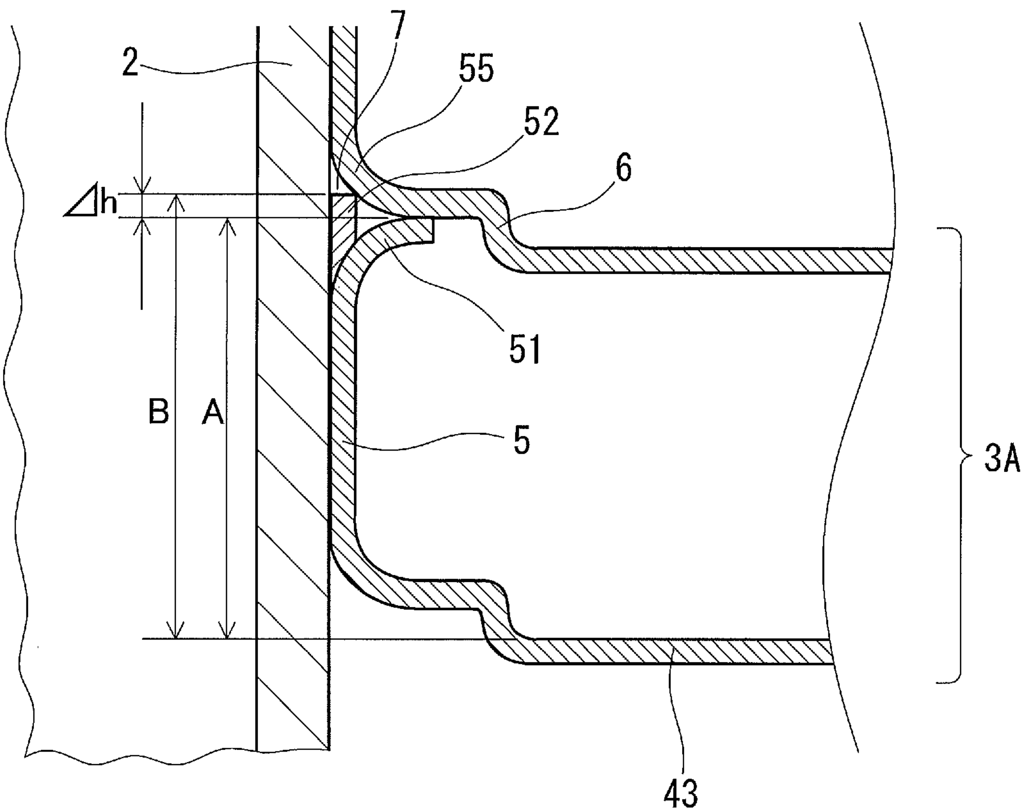

FIG.5

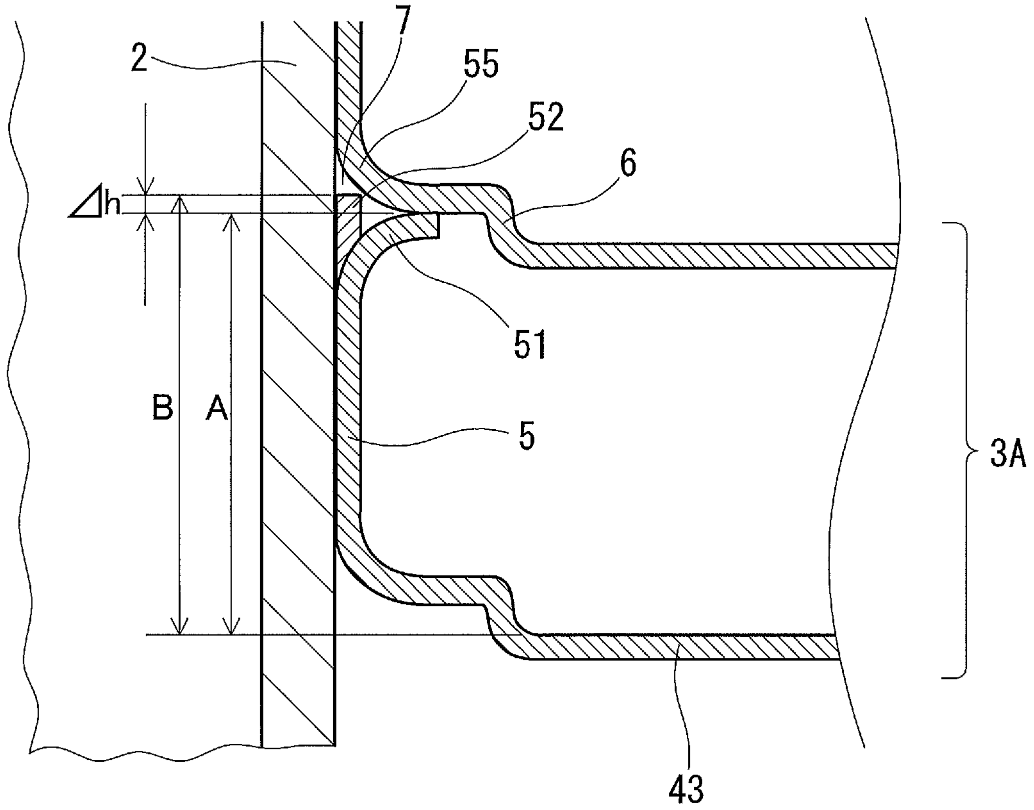

FIG.6

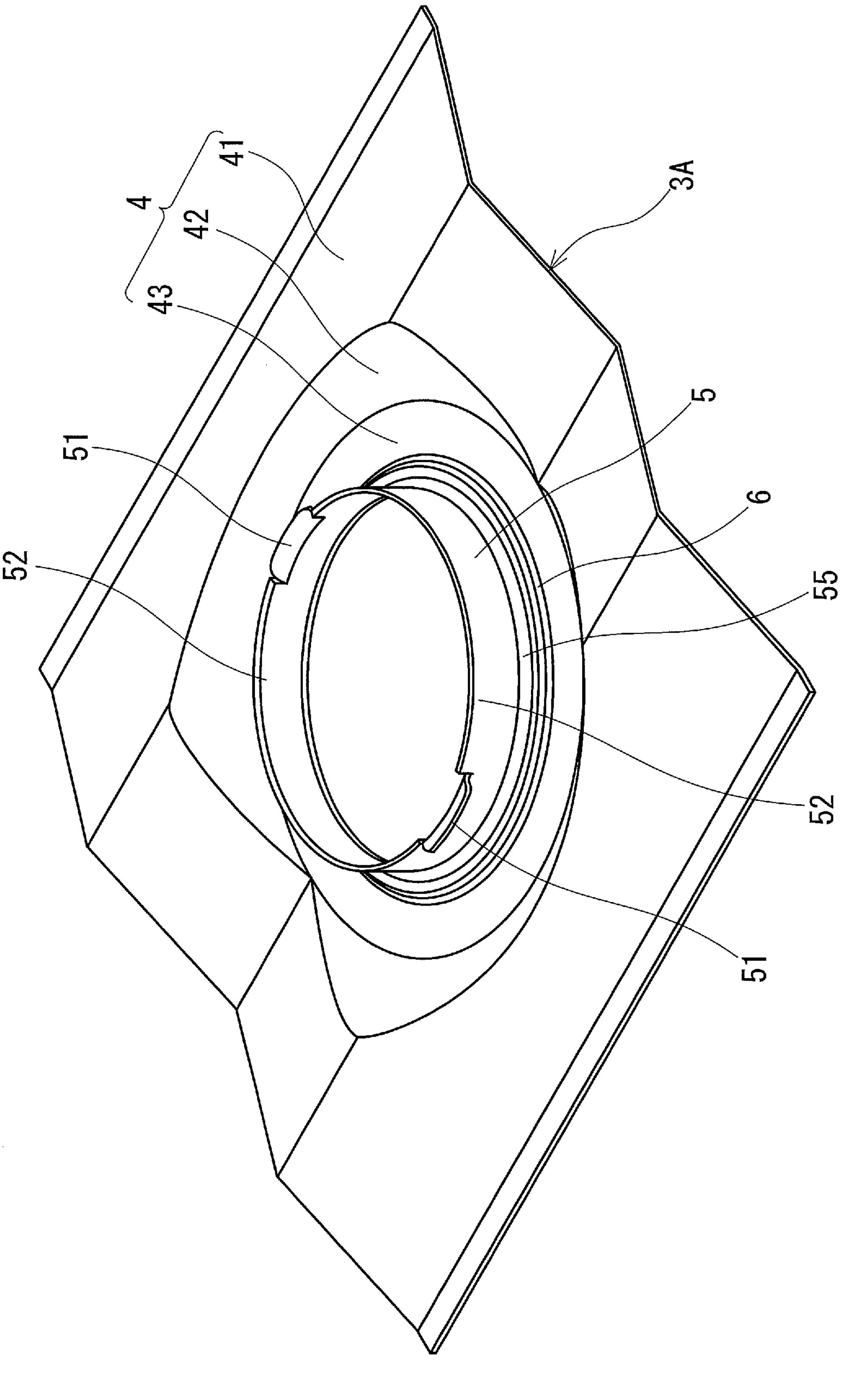

FIG.7

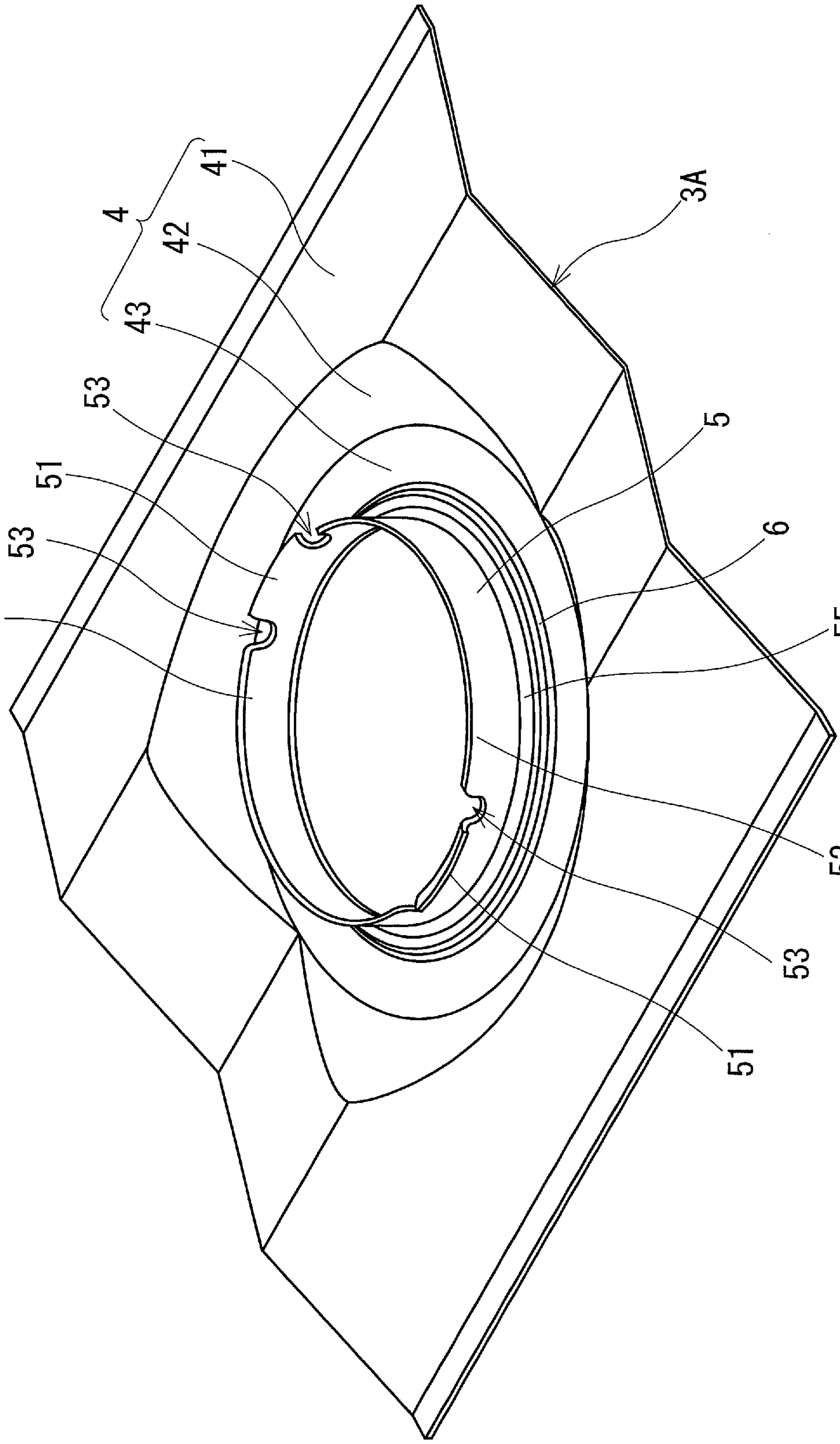

FIG.8

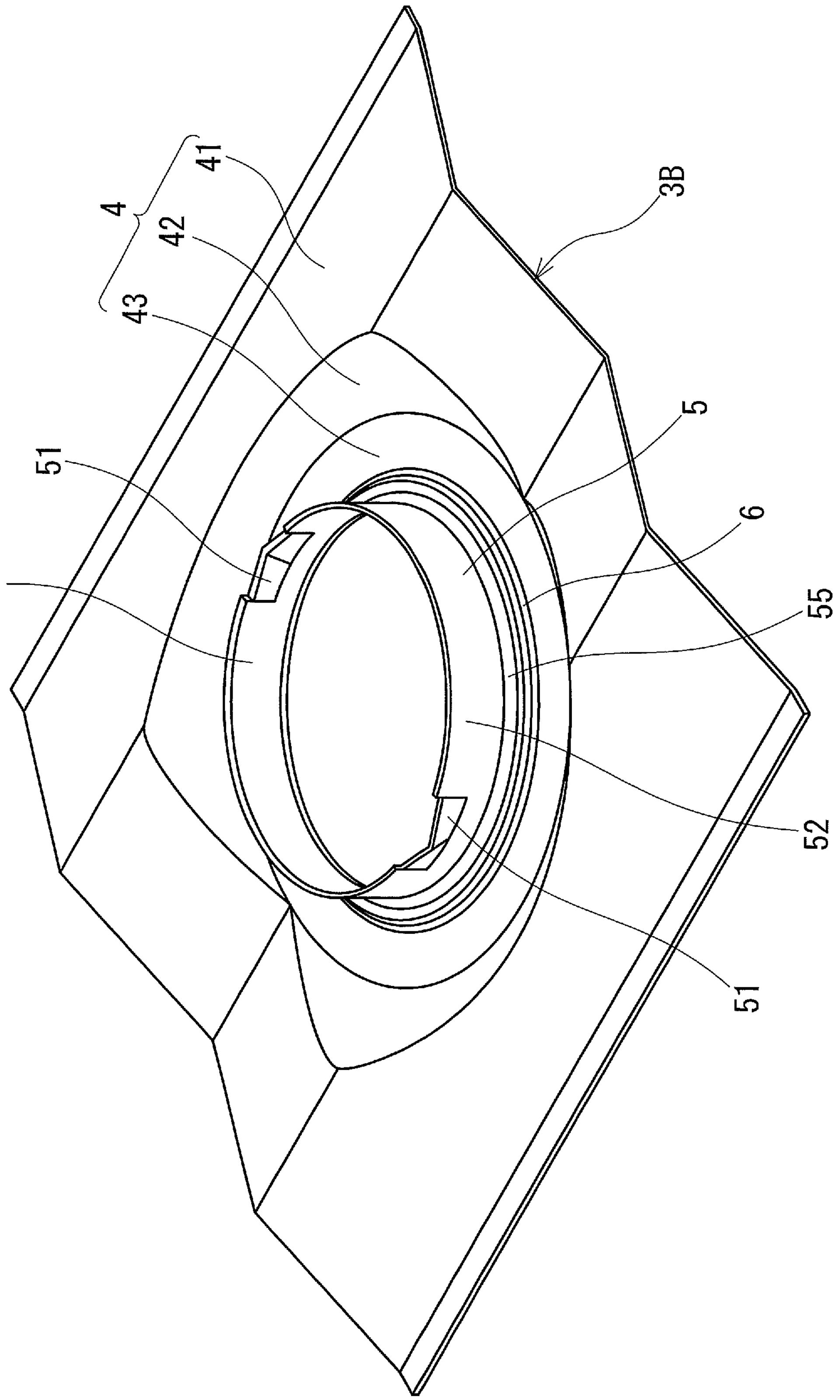

FIG.9

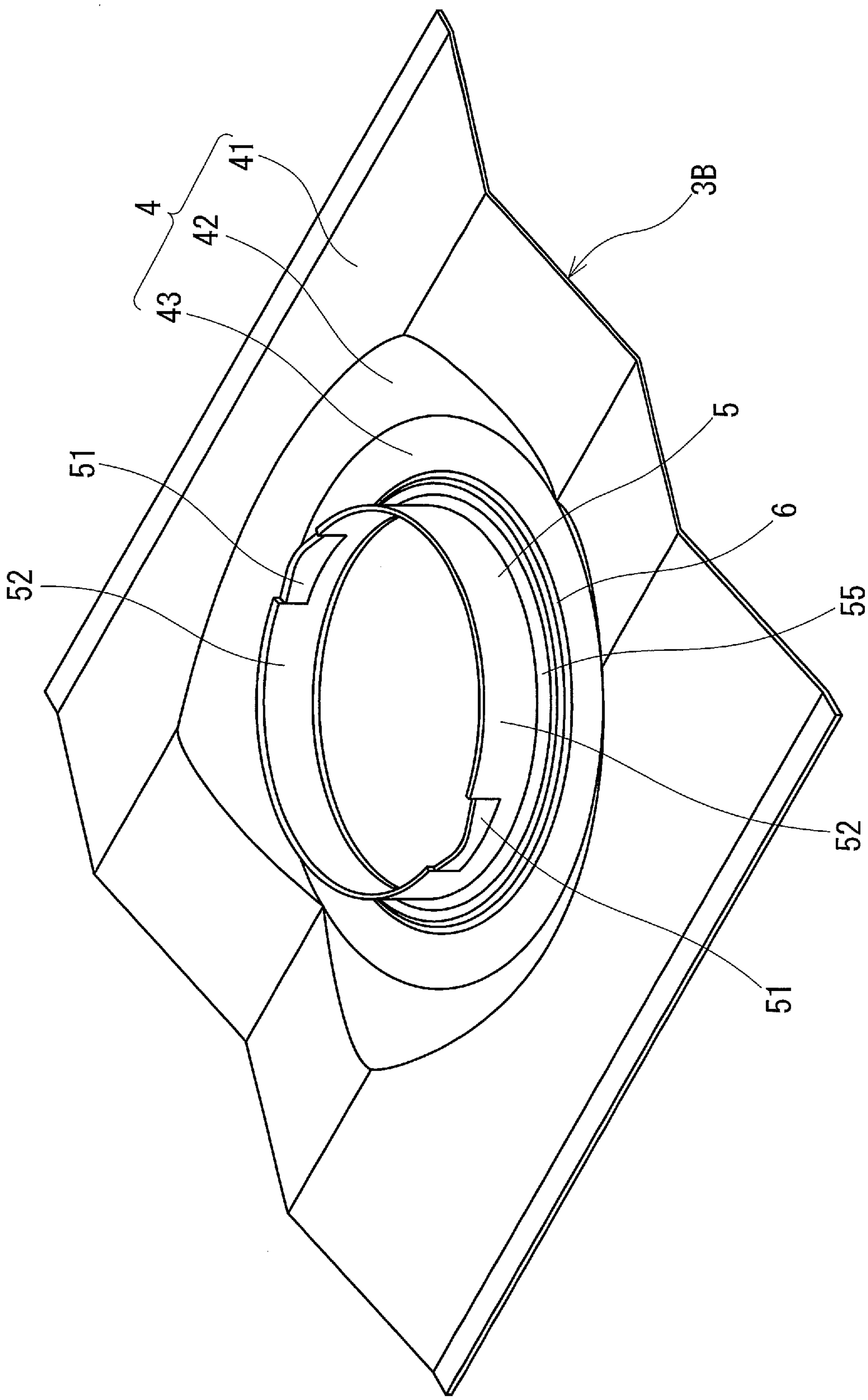

FIG.10

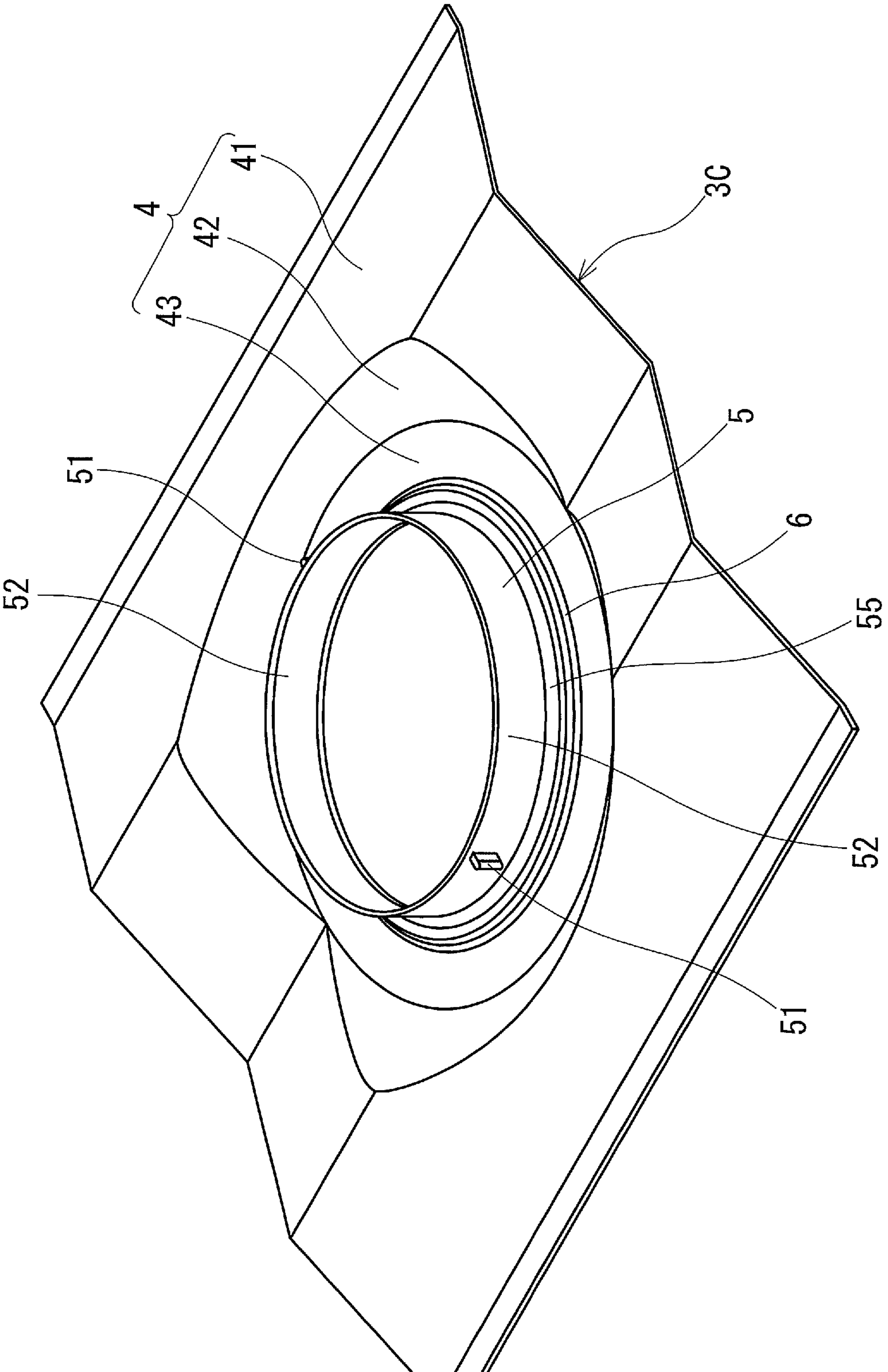

FIG.11

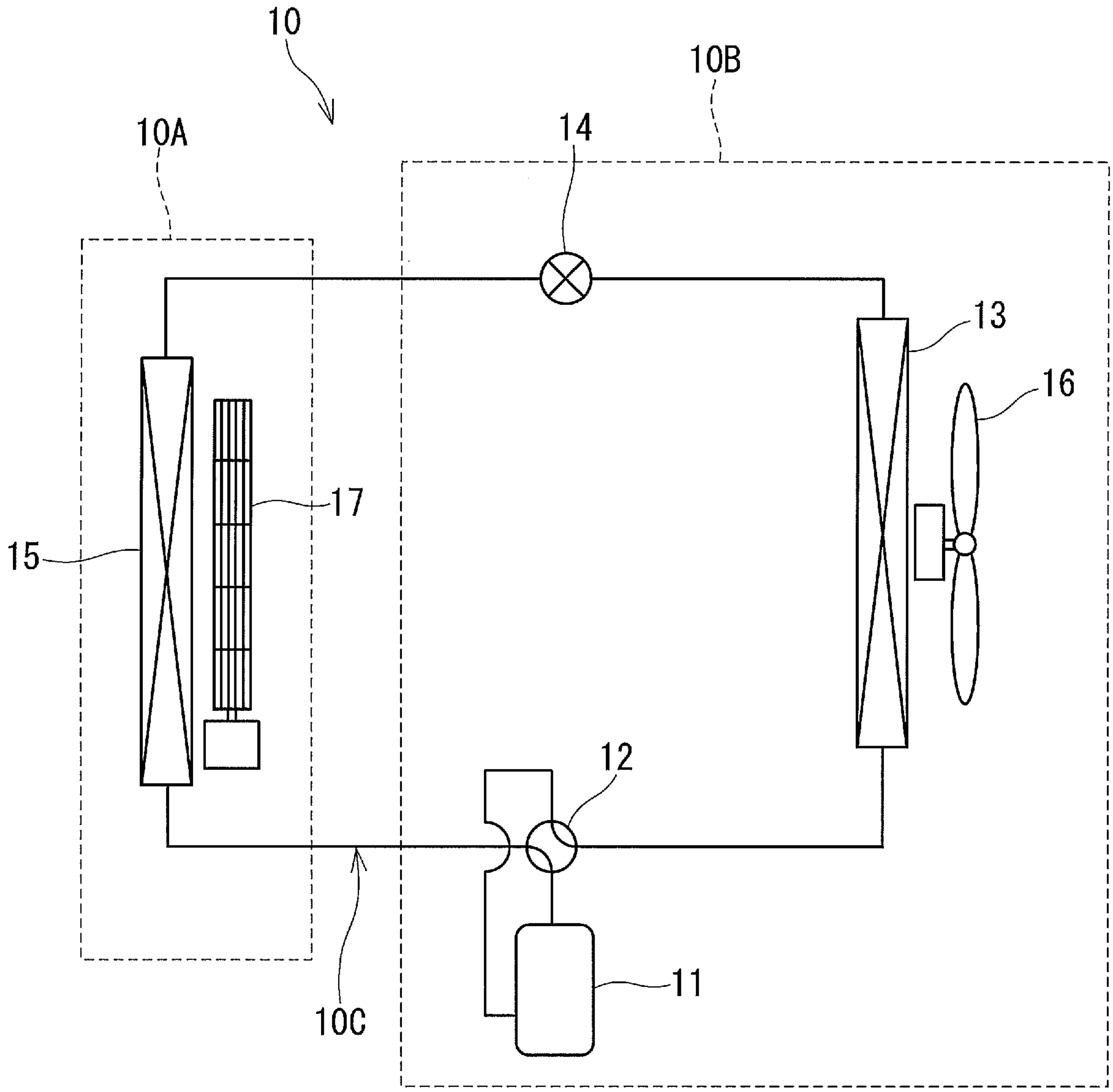

FIG.12

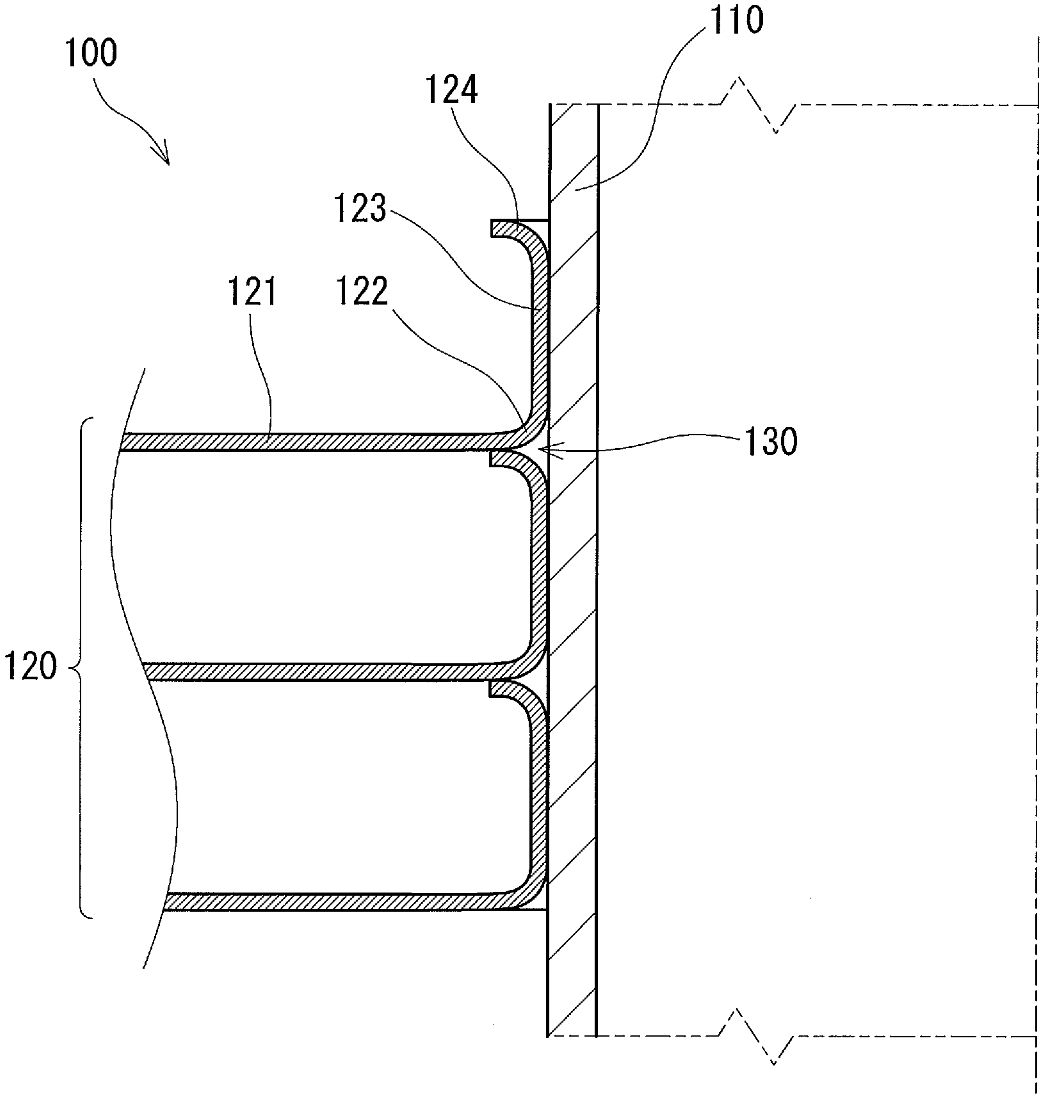

FIG.13

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/007197

A. CLASSIFICATION OF SUBJECT MATTER
F28F1/32(2006.01)i, *F25B39/00*(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F28F1/32, F25B39/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2013
Kokai Jitsuyo Shinan Koho	1971-2013	Toroku Jitsuyo Shinan Koho	1994-2013

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	JP 2011-64403 A (Mitsubishi Electric Corp.), 31 March 2011 (31.03.2011), fig. 1, 2, 4 to 6; paragraphs [0019] to [0023] (Family: none)	1-3,12-14 4,15
Y	JP 58-127092 A (Nippondenso Co., Ltd.), 28 July 1983 (28.07.1983), fig. 13; page 4, lower left column, lines 2 to 4 (Family: none)	4,15
A	US 5706695 A (Werner HELMS), 13 June 1998 (13.06.1998), entire text; all drawings & US 5706695 A & US 5582244 A & EP 672882 A1 & DE 4404837 A1 & DE 4404837 A1 & ES 2123089 T	1-4,12-15

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search 11 January, 2013 (11.01.13)	Date of mailing of the international search report 22 January, 2013 (22.01.13)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/007197

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:
See extra sheet.

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:
1-4 and 12-15

Remark on Protest
☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/007197

Continuation of Box No.III of continuation of first sheet(2)

Disclosed in Document 1 (JP 2011-64403 A (Mitsubishi Electric Corp.), 31 March 2011 (31.03.2011)) (see fig. 1, 2, and 4 to 6, and paragraphs [0019] to [0023]) is a fin tube type heat exchanger which includes a plurality of heat transfer fins (1) stacked one on another and a heat transfer pipe (2) which penetrates through the plurality of heat transfer fins. The heat transfer fin includes a base (10), a cylindrical collar (14) erected from the base, a flared portion (15) which is formed by part of a tip end portion of the collar being flared from the tip end of the collar outwardly in the radial direction of the collar, and a wall which is formed by the tip end portion of the collar extending to a region other than the flared portion. The height of the wall from the base is greater than the height of the flared portion from the base. At least two flared portions are provided in a manner such that one of the at least two flared portions extends in one direction, whereas the other of the at least two flared portions extends in a direction opposite to the one direction.

Therefore, the inventions of claims 1-3 and 12-14 cannot be considered to be novel in the light of the inventions disclosed in the document 1, and have no special technical feature.

Accordingly, ten inventions (invention groups) each having a special technical feature indicated below are involved in claims.

Meanwhile, the inventions of claims 1-3 and 12-14 having no special technical feature are classified into invention 1.

(Invention 1) the inventions of claims 1-4 and 12-15

The heat transfer fin wherein the one direction is orthogonal to the longitudinal direction of the heat transfer fin.

(Invention 2) the inventions of claims 5 and 16

The heat transfer fin wherein the one direction is within the angular range of +/-30 degrees relative to a straight line extending from the center of the collar in the width direction orthogonal to the longitudinal direction of the heat transfer fin.

(Invention 3) the inventions of claims 6 and 17

The heat transfer fin wherein the flared portion is constructed to be bent radially outwardly with increasing distance from the tip end of the collar.

(Invention 4) the inventions of claims 7 and 18

The heat transfer fin wherein there is provided a notch between the flared portion and the wall.

(Invention 5) the inventions of claims 8 and 19

The heat transfer fin wherein the flared portion is shaped in a manner such that the center of the flared portion is bowed outwardly from the outer circumferential surface of the cylindrical body that forms the collar.

(Invention 6) the inventions of claims 9 and 20

The heat transfer fin wherein the flared portion is a projection which is provided on the outer circumferential surface of the cylindrical body that forms the collar.

(Invention 7) the inventions of claims 10, 11 and 23-26

The heat transfer fin comprising a step height portion which is curved at the root of the collar to continue to the base so as to form a recess.

(Continued to next extra sheet)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/007197

(Invention 8) the invention of claim 21

The fin tube type heat exchanger wherein the wall of one of the heat transfer fins stacked one on another is in contact with the rear surface of the root of the collar of another heat transfer fin stacked on the one heat transfer fin.

(Invention 9) the invention of claim 22

The fin tube type heat exchanger wherein the wall of one of the heat transfer fins stacked one on another is not in contact with the rear surface of the root of the collar of another heat transfer fin stacked on the one heat transfer fin.

(Invention 10) the invention of claim 27

A heat pump device comprising a compressor, a condenser, a throttle, an evaporator, and a refrigerant circuit for circulating a refrigerant through the compressor, the condenser, the throttle, and the evaporator, wherein at least one of the condenser and the evaporator is the fin tube type heat exchanger set forth in claim 12.

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2010169344 A **[0006]**